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EMPIRICAL ANALYSIS OF PASS THROUGH OF EXCHANGE RATE AND ITS VOLATILITY TO INFLATION IN SELECTED EMERGING ECONOMIES

Mehak EJAZ* and Qadeer KHALID**

Abstract

This study explores the pass-through of unanticipated movements in growth and variance of exchange rate to inflation. First, it quantifies the volatility of the exchange rate by using the GARCH-X model. Foreign exchange reserves are considered as an exogenous variable that plays an instrumental role in stabilising the exchange rate. Second, the SVAR model is estimated to identify the responses of inflation to unanticipated shocks. The results indicate that there is a direct relationship between exchange rate volatility and inflation in the economies where the volatility is relatively high, such as Pakistan, India, Indonesia, the Philippines, and Turkiye. While, in economies with flexible exchange rate regimes and less volatile exchange rates, volatility tend to have either a negative or minimal effect on inflation. The findings on the effect of unexpected exchange rate fluctuations on inflation align with economic theory. Countries like Pakistan, India, Indonesia, Malaysia, Hungary, Egypt, Georgia, and Poland, which experience greater exchange rate volatility, exhibit a positive pass-through to inflation. Consequently, the study concludes that exchange rate stability is crucial for controlling inflation in emerging economies. Additionally, the study suggests that these countries should prioritize building adequate foreign exchange reserves, and emphasizes the importance of central bank independence in monetary policy decision-making.

Keywords: Pass through of Exchange Rate, Exchange Rate Volatility, Inflation, Emerging Economies, GARCH, Exchange Rate Regimes, Foreign Exchange Reserves, SVAR, Impulse Responses.
JEL Classification: C51, E31, E58, F31.

I. Introduction

Since the end of the Bretton Woods system in the 1970s, exchange rate fluctuations have become a major source of concern for world economies [Battilossi, et al., (2004)]. Following the Bretton Woods system, most economies switched towards a more flexible exchange rate system.[1] Many countries have liberalised their economies as a result of the success of flexible exchange rate systems, which has increased coordination,

* Associate Professor, Institute of Business Management (IoBM), **Economist, State Bank of Pakistan, Karachi, Pakistan.

[1] International Monetary Fund (IMF). 2001, Global Trade Liberalization and the Developing Countries. https://www.imf.org/external/np/exr/ib/2001/110801.htm#i

cooperation and global trade among economies that benefit from globalisation [IMF (2001)]. This transition to a market-determined exchange rate has sparked a new round of debate among theorists and policymakers. In order to avoid the repercussions of undue fluctuations in the exchange rates, emerging economies have managed their currencies through monetary and fiscal policies. The exchange rate improbability turned into a precarious issue for policymakers since there is a lack of consensus on the impact of exchange rate volatility on external trade activity. The volatility of exchange rates has increased significantly since the switching towards flexible exchange rates and the use of monetary policy for inflation targeting [Boug and Fagereng (2010)]. Boug and Fagereng (2010) discover a coincidental relationship between the growth in exports and the volatility of exchange rates in various economies. Asteriou, et al., (2016) and Nazlioglu (2013) also predict exchange rate volatility for Nigeria, Mexico, Turkiye, and Indonesia.

After Boug and Fagereng (2010), Asteriou, et al., (2016), and Nazlioglu (2013), and many other studies quantified exchange rate volatility to find the holistic effect of volatility on various emerging economies because unsustainable economic growth, subsistence level of reserves and intermediate income affect these countries' exchange rate volatility. Foreign investors, inter alia, consider exchange rate dynamics before investing in the country. There are ample studies in economics literature which state that a high level of volatility dampens investors' confidence. Their respective central banks control the monetary policy of the emerging economies. The main objective of central banks is to stabilise prices using monetary policy tools, especially the interest rate and money supply (M2). In addition, the exchange rate is considered as an important tool of monetary policy in the emerging economies. Nevertheless, under some common assumptions, central banks adjust the interest rates to influence exchange rate movements. As a result, there is a need to figure out how the monetary policy passes through to the "Exchange Rate Volatility" and vice versa.

Hypothetically, economies do not require reserves under a flexible exchange rate regime. However, countries still prefer to hold international reserves as a precautionary measure for any unavoidable shocks that can cause exchange rate volatility. Therefore, despite the flexible exchange rate in most of the emerging economies, the requirement of reserves still exists. In view of the aforementioned discussion, since 1990s, global foreign exchange reserves have increased progressively, especially in emerging economies. The emerging economies' foreign reserves have also improved, including India's $640, Pakistan's $17, Indonesia's $144.8, Philippines's $107, Turkiye's $121, Russia $638, Georgia $3.7, Malaysia $115, Egypt $40 and Poland's $169 in billions. Amid the swelling financial imbalance, an upsurge in forex reserves in emerging economies has garnered the attention of policymakers, academics, and financial market investors, which has led to some controversies. Bernanke (2005) claim that an extraordinary amount of forex reserves led to excessive savings, hence causing global imbalances.

Moreover, exchange rate volatility in the currencies of emerging economies is being curtailed by maintaining reserve assets. Therefore, reserve assets act as an exogenous variable that can impact the exchange rate and can be controlled by the government to limit exchange rate volatility. Thus, we use forex reserve as an additional exogenous variable in modelling GARCH-X. The recent change in the level of international forex reserves and volatility in exchange rates in emerging markets has prompted more significant interest in debates on movements in exchange rates in emerging markets due to the unusually high levels of exchange rate volatility compared as to developed economies [Darrat and Hakim (2000)]. One of the issues with emerging markets is that no significant empirical evidence exists to support the idea that they will experience exchange rate volatility and which types of exporting countries they will focus on. The figures highlighted that exports are rising but do not explicitly state whether exchange rate instability was a factor in holding back the export progress.

It is true that under some assumptions, central banks use interest rate adjustments to stem exchange rate movements, while under other assumptions, they let exchange rate movements affect interest rates. In order to know what impact policy decisions will have, there is a need to determine which monetary policy tool causes exchange rate volatility. Many emerging economies have switched from monetary aggregate targeting to inflation targeting, which is a more flexible approach. Since then, the majority of emerging economies have followed a market-based exchange rate mechanism in which central banks intervene when necessary to maintain the stability and smoothness of the exchange rate. Emerging economies import a wide range of goods, including finished goods and a variety of manufacturing inputs. Therefore, any adjustment in the exchange rate would impact import prices, potentially increasing the cost of finished goods in the domestic market and leading to inflation. An adjustment like this will result in a major pass-through to domestic prices. Therefore, this study also tries to quantify Exchange Rate Pass-through (ERPT) for emerging economies.

Several studies have been conducted in the domain of ERPT on monetary policy and inflation. While most studies focus on ERPT to inflation and monetary policy, fewer studies have been conducted on Exchange Rate Volatility Pass-Through (ERVPT) to monetary policy, inflation and vice versa. An important feature that should have been included in these studies was that they ignored the role of reserves, which has important implications in explaining the volatility of exchange rates, especially in the context of economies like Pakistan, Egypt, and Turkiye. It has been observed that countries with less reserves experience much volatility in their exchange rate. Therefore, this study will fill that gap for emerging countries by examining the role of reserves in exchange rate volatility to gauge pass-through to monetary policy in emerging economies. This study will also analyze the degree of volatility given the central bank's intervention in forex markets. Specifically, the objective is to measure the exchange rate volatility of selected emerging economies through the GARCH-X model and to quantify its impact on Monetary Policy and inflation in emerging economies. It also

incorporates reserve assets of the respective country as exogenous explanatory variables in the GARCH-X model.

This study will benefit central banks when they formulate monetary policy and governments when they determine the impact that exchange rate volatility has on the macroeconomic environment and stability. In addition, this study will help foreign investors account for exchange rate volatility while making their investment decisions in emerging economies, especially highlighting the need to consider a country's reserve position before investing. Lastly, the study will help consumers predict the demand for commodities of foreign products while taking into account the exchange rate volatility.

After the introduction in Section I, Section II synthesizes the pertinent literature on exchange rate and inflation. Econometric Methodology is discussed in Section III; while, results and conclusions are presented in Sections IV and V, respectively.

II. Literature Review

Exchange Rate Pass-Through (ERPT) garnered the interest of researchers exploring the dynamics and determinants across emerging and developing economies. Taylor's (2000) seminal contribution highlights the ERPT to inflation, revealing low pass-through in low inflation periods. Taylor explores the phenomenon that if agents perceive exchange rate movements as short-term, they may absorb temporary hits on markups instead of adjusting rates immediately. Choudhri and Hakura (2006) empirically test Taylor's hypothesis for a sample of 71 countries, spanning 1979 to 2000, finding a clear and significant positive ERPT. Edwards (2006) probes ERPT in inflation-targeting economies, finding indicate significant variations among the developed and developing nations before and after adopting this policy framework. He finds a significant slowdown in pass-through in inflation-targeting countries.

The role of exchange rate volatility emerges as a crucial factor influencing ERPT. Floden and Wilander (2006) establish a positive and significant relationship between Exchange Rate Volatility (ERV) and ERPT, while López-Villavicencio and Mignon (2021) find that ERPT decline is associated with more stable environments in emerging countries. Campa and Goldberg (2005) argue that the composition of imports also plays a pivotal role. They contend that shifting toward industries with low pass-through elasticities reduces aggregate import pass-through. Additionally, the degree of the pass-through is influenced by the interchangeability of imported and domestically manufactured goods and the level of dollarization in an economy. Frankel, et al., (2012) identify several predictors of ERPT, including per capita income and the composition of trade. Kohlscheen (2010) employs a VAR model to assess the reflection of exchange rate changes in consumer prices, finding that countries with more volatile nominal exchange rates and those trading homogeneous products experience higher pass-through.

Further regional studies contribute to the understanding of ERPT dynamics. In East Asian countries, Ito and Sato (2008) observe a decline in pass-through sideways

the distribution chain, with consumer prices exhibiting the lowest degree. Similarly, in Latin American countries, Ghosh (2013) finds that ERPT has decreased over the decades, with Brazil experiencing a long-run pass-through of 0.47 in year 2000s. Studies evaluating the impact of specific policies on ERPT reveal interesting insights. Nogueira and León-Ledesma (2009) report a substantial weakening in pass-through in Brazil after inflation targeting was implemented in 1999.

Similarly, Prasertnukul, et al., (2010) find that inflation targeting in Asian countries, such as South Korea and Thailand, led to a drop in pass-through. Contrasting these findings, Aleem and Lahiani (2014) introduce the concept of non-linear ERPT, indicating that pass-through becomes significant when inflation exceeds a threshold. Odria, et al., (2012) and Winkelried (2014) investigate the impact of inflation targeting in Peru, demonstrating a substantial reduction in pass-through.

ERPT is a complex phenomenon influenced by exchange rate volatility, inflation, import composition, and policy frameworks. Over time, regional variations and ERPT's evolving nature contribute to the rich tapestry of research in this field.

The economic impacts of exchange rate volatility (ERV) have sparked enduring debates among economists, highlighting divergent perspectives. Earlier studies, such as Obstfeld and Rogoff (1998), assert that substantial fluctuations in exchange rates have adverse effects on domestic economies. Devereux and Engel (2003), however, argue that the welfare implications of ERV hinge on pricing mechanisms.

The discourse surrounding ERV-growth dynamics unveils various factors of exchange rate volatility. In seminal models, Dornbusch (1976), unexpected shocks of monetary policy yield pronounced exchange rate fluctuations, briefly affecting the real exchange rate. This triggers a division in contemporary research into two realms: one probing the link between real exchange rate —supply and demand variables, and the Balassa–Samuelson hypothesis—and ERV. The other examines the impact of actual shocks on currency volatility. Studies by Clarida and Gali (1994), Gauthier and Tessier (2002), and Kandil and Mirzaie (2008) delineate the roots of exchange rate fluctuations, attributing them to business cycle shocks, supply-side dynamics, and unexpected currency movements. Due to their susceptibility to shocks, developing nations often exhibit higher ERV than developed economies.

Moreover, external financial liabilities and institutional factors, as noted by Hausman, et al., (2006), play a role in mitigating ERV. However, scepticism persists regarding ERV's welfare implications. Devereux and Engel (2003) contend that exchange rate uncertainty does not necessarily equate to welfare costs, especially when costs are denominated in foreign currencies.

Further investigations by Benita and Lauterbach (2007), Habibullah, et al., (2005), Barguellil, et al., (2018), Aristotelous (2001), Vita and Abbott (2004), Ullah, et al., (2012), Beine, et al,. (2003), Guimaraes (2004), and Lee and Boon (2007) delve into ERV's multifaceted impacts. These studies explore ERV's relationship with central bank interventions, exports, economic growth, exchange rate regimes, foreign direct

investment, and macroeconomic factors across diverse regions and periods. In conclusion, the discourse on ERV spans a spectrum of factors and their intricate interplay, shedding light on its complex implications for economies globally.

The exchange rate and its volatility pose challenges due to limited convertibility and global demand in Pakistan. Tying these currencies to widely accepted ones eases trade, capital flow, and reserve management, a decision requiring careful consideration [Siddiqui (2009)]. Over time, Pakistan enacted financial reforms, opening capital markets and adopting a flexible exchange rate policy. However, the PKR has consistently fallen against the U.S. dollar since 1970, dropping from Rs. 4.78 to Rs. 87.16 in the first decade of the 21st century—a decline of over 18 times in value [Siddiqui (2009)]. Pakistan's foreign exchange system has seen complexity; initially, it was pegged with the pound sterling of the U.K. and then shifted to the U.S. in the early 1970s at Rs.4.76 per USD. Various exchange rate regimes, from fixed to regulated floating systems, were categorized into USD-denominated rates, floating interbank currency rates, and combinations thereof [Siddiqui (2009)]. The State Bank of Pakistan regulated the U.S. exchange rate while allowing local banks to set rates for other currencies based on market conditions. During the initial years of the 2000s, regulations regarding band limits were removed, freeing the Pakistani rupee to float and allowing market forces to determine its value [Qayyum and Kemal (2006)].

In emerging markets, the impact of ERV on various economies is explored extensively. Dhameja and Jain (2014) explore India's transition in exchange rate regimes, while Elsherif (2016) investigated Egypt's exchange rate volatility using a GARCH model. Steel and King (2004) studied exchange rate pass-through in New Zealand, finding a reduction under a floating regime. Shah, et al., (2009) focus on Pakistan's central bank intervention, highlighting its effectiveness in managing exchange rate volatility. Panda and Mohanty (2015) observe a decrease in Indian exports due to exchange rate volatility. Schmidt-Hebbel and Tapia (2002) examine the targeting of inflation in Chile, showcasing its impact on policy evolution and stability.

Similarly, Syarifuddin, et al., (2014) explore Indonesia's response to exchange rate volatility. Kutu and Ngalawa (2016) analyze Russia's exchange rate volatility using the GARCH and APARCH models, finding no leverage effect. Abu Asab (2015) explores the impact of inflation targeting and fixed exchange rate systems on reducing inflation uncertainty. Aftab, et al., (2016) discover the influence of the exchange rate volatility on the Malaysia-Thailand trade flows, affecting specific industries. Goldfajn and Werlang (2000) observe increased pass-through coefficients with longer horizons, while Asteriou, et al., (2016) finds short-term causal relationships between currency volatility and import/export demand in some countries. Caporale, et al., (2017) studied the volatility of exchange rates in emerging Asian economies, associating it with international portfolio flows. However, there is a gap in understanding the role of forex reserves in determining exchange rate volatility and its implications for monetary policy, especially in emerging economies like Pakistan, Egypt, and Turkiye. This gap motivates further research to explore the contribution of forex reserves in determining the volatility of exchange rates and its impact on monetary policy using SVAR models.

1. Evidence from Literature Review

The exchange rate and inflation volatility experienced by countries such as Pakistan, India, Indonesia, and the Philippines have reflected diverse economic trajectories and policy response (Figure A-2 to A-5 in Appendix). Pakistan has grappled with high inflation and fluctuating exchange rates, influenced by political instability and economic mismanagement. While facing its challenges, India has generally maintained more stability due to structural reforms and a growing economy. However, recent years have seen some volatility linked to global economic uncertainties. Indonesia and the Philippines have shown a mixed pattern, with Indonesia facing currency pressures due to its reliance on commodity exports and the Philippines managing to moderate inflation through effective monetary policy and economic growth.

In Eastern Europe and Central Asia, countries like Ukraine, Turkiye, and Russia have experienced significant volatility in both exchange rates and inflation, driven by geopolitical tensions and domestic economic issues (Figure A-6 to A-8 in Appendix). Ukraine's economic instability, exacerbated by conflicts, has led to severe currency fluctuations and high inflation. Turkiye has struggled with persistent inflation and an unstable lira, partly due to unconventional monetary policies and political pressures. Russia's economy has faced volatility due to international sanctions and fluctuating oil prices. Meanwhile, as members of the European Union, Poland and Hungary have experienced more moderated volatility, although Hungary has faced recent inflationary pressures (Figure A-9 to A-10 in Appendix). Malaysia and Thailand, on the other hand, have navigated their economic challenges, with Malaysia dealing with commodity price shocks and Thailand experiencing periods of political instability affecting its economic stability (Figure A-11 to A-12 in Appendix). Lastly, inflation in Egypt and Georgia have been volatile due to the change in regime and external shocks (Figure A-13 to A-14 in Appendix).

III. Theoretical Framework

The literature synthesis indicates that the exchange rate (local currency relative to US$) is an important determinant of inflation in emerging economies. Exchange rate movements impact inflation through the increase in prices of imported products and items that use imported inputs and the formation of inflation expectations. Therefore, inflation can be determined by the following Equation (1).

$$Inf_t = f\,(ER_t,\, Z_t) \tag{1}$$

where Inf_t and ER_t are the growth rates of consumer prices and exchange rates at time t, and Z_t is the vector of controlled variables, which includes interest rates and economic activity indicators, among others.

The volatility of the exchange rate also plays an important role in impacting the prices [Betts and Devereux (2000), Elsherif (2016), Kutu and Ngalawa (2016) and As-

teriou, et al., (2016)]. Further, there is also evidence that markups are impacted by exchange rate shocks [Kaufmann and Renkin (2018) and Steiner (2024)]. Based on the literature, it is hypothesized that fluctuations in exchange rate impact the inflation in emerging economies, leading toward the specification as follows in Equation (2):

$$Inf_t = f\,(ER_t,\ ER\sigma_t^2,\ Z_t) \tag{2}$$

IV. Econometric Methodology

This section presents the conceptual framework for analyzing the pass-through of the exchange rate and its volatility to inflation. The method to calculate volatility, econometric models, data sources and variables are discussed. The methodology starts with the simple specification of the ARIMA model of exchange rate determinations. With the confirmation of its stationarity, first difference of the log of exchange rate is considered as dependent variable in Equation (3).

$$\Delta er_t = \mu + \Phi_1 \Delta er_{t-1} + \cdots + \Phi_p \Delta er_{t-p} + \theta 1\, e_{t-1} + \cdots + \theta_q\, e_{t-q} + v_t \tag{3}$$

The ARIMA model assumes constant mean and variance over time. However, the presence of the Autoregressive Conditional Heteroskedastic (ARCH) effect in the logarithmic -difference of exchange rate series is tested by using the following equation. The ARCH (1) model is expressed in the Equation (4).

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 \tag{4}$$

where $\varepsilon_t \mid I_{t-1} \sim N(0,\ \sigma_t^2)$ and α and ω are constants. Further, there is the possibility of a GARCH component in the model. Therefore, the GARCH specification is presented in Equation (5) and (6). Bollerslev (1986) developed generalized ARCH models to solve the problems that come with large lag lengths (q), such as more parameters to be estimated and the increasing non-negative restrictions on parameters. The GARCH (p, q) model is as follows:

$$r_t = X_t \beta + \varepsilon_t \tag{5}$$

where $\varepsilon_t \sim D(0,\ \sigma_t^2)$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i\, \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i\, \sigma_{t-i}^2 \tag{6}$$

where $\varepsilon_t = z_t\, \sigma_t,\ z_t \sim N(0,1)$

In Equation (5), r_t indicates exchange rate growth, which is determined by a vector of endogenous and exogenous variables denoted by X_t, and β is a vector of

regression parameters. Empirically, $X_t \beta$ represents ARIMA (m, n) structure. In Equation (4), $\alpha_0 > 0$, $\alpha_i \geq 0$, $\beta_i \geq 0$, and $\sum \alpha_i + \sum \beta_i < 1$ are necessary conditions for the variance-covariance stationary model.

Exchange rate series are discovered to be a highly peculiar sort of series that exhibit leptokurtosis with heavy tails, implying non-normal distribution, and that assumption regarding normality for standardized residuals needs to be loosened. Bollerslev (1987) weakens this particular assumption and suggests the GARCH-t model, in which $\varepsilon_t = z_t \sigma_t$; $z_t \sim t(0,1,v)$. There is an additional parameter to estimate (v), which is the degree of freedom of the student's t distribution. Finally, GARCH-X (p, q) is considered for the volatility of the exchange rate with exogenous regressors. The equation of the GARCHX (p, q) model with conditional mean along with conditional variance is as follows in Equation (7):

$$r_{t,a} = X_t \beta + \theta_1 r_{t,b} + \varepsilon_t \tag{7}$$

where $\varepsilon_t \sim D(0, \sigma^2_t)$

$$\sigma^2_{t,a} = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon^2_{t-i} + \sum_{i=1}^{p} \beta_i \sigma^2_{t-i} + \theta_2 r^2_{t,b} \tag{8}$$

where $\varepsilon_t = z_t \sigma_t$, $z_t \sim N(0,1)$

In Equation (7) $r_{t,a}$ are the returns on the exchange rate, In Equation (8) $\alpha_0 > 0$, $\alpha_i \geq 0$, $\beta_i \geq 0$, and $\sum \alpha_i + \sum \beta_i < 1$ denote the essential conditions for a variance-covariance stationary model. The coefficient θ_2 captures the volatility spillover from series b to series a. The present study uses the SVAR method to retrieve the pass-through of the exchange rates and their volatility for selected emerging countries. The specification for the vector of variables in the model is given below in Equation (9).

$$X_t = (\Delta lnCPI_t, \Delta lnRER_t, \Delta lnTbill_t, \Delta lnVER_t) \tag{9}$$

where X_t is a vector of variables, CPI_t = Consumer price index, RER_t = Real exchange rate, $Tbill_t$ = Treasury bill rate, VER = Volatility of Exchange rate estimated through GARCH-X model and Δ = Difference operator.

The standard VAR model is specified as follows in Equation (10);

$$X_t = \varphi + \Gamma_1 X_{t-1} + \Gamma_2 X_{t-2} + \Gamma_3 X_{t-3} + \cdots + \Gamma_k X_{t-k} + u_t \tag{10}$$

It can be noted that Γ_i is the matrices of coefficients to be estimated. However, X_t is a vector of endogenous variables while u_t is a vector of innovations that might be contemporaneously correlated and φ is a vector of constants. The reduced-formed VAR residuals (u_t) and the structural shocks (ε_t) can be specified as follows:

$$\begin{pmatrix} u_t^{EX} \\ u_t^{CPI} \\ u_t^{Tbill} \\ u_t^{VER} \end{pmatrix} = \begin{pmatrix} S_{11} & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{EX} \\ \varepsilon_t^{CPI} \\ \varepsilon_t^{Tbill} \\ \varepsilon_t^{VER} \end{pmatrix}$$

The structural shock (u_t) is identified by determining the order of the four variables of interest and then decomposing the variance-covariance of reduced-form residuals (ε_t) using Cholesky decomposition. To be certain, in this regard, the order of the variables is critical. A movement of interest rate is used to quantify monetary disturbances. By encapsulating an aggressive monetary policy shock, it gains the ability to influence a country's exchange rate [Saha and Zhang (2016)]. The exchange rate shock is then assigned a value that allows it to adjust in response to the demand shock. Thus, in order to obtain meaningful results, diagnostic tests must be considered. For example, the variables used in the analysis should be stationary. There are numerous tests available in the literature, but this study employs statistical tests and diagnostic procedures for addressing the aforementioned basic time series properties. Augmented Dicky and Fuller tests were frequently used to determine stationary requirements. To estimate exchange rate volatility, the study needs to have data on exchange rates from the selected emerging countries. The selected countries are Pakistan, India, Bangladesh, Indonesia, Malaysia, Philippines, Thailand, Hungry, Turkiye, Ukraine, Russia and Georgia. The selection of the country is based on the availability of data on the exchange rate regime. Countries having free floating and managed floating exchange rate regimes are selected, and the countries with fixed exchange rate systems have been dropped.

TABLE 1

Definition of Variables and their Sources

Variable	Definition	Measurements	Frequency	Source
RER_t	Nominal effective exchange rate adjusted with inflation.	Average Monthly Data in Local Currency over USD	2000m01-2024m06	Haver Analytics
CPI_t	Consumer Price Index	Monthly data in percentage change over the previous year	2000m01-2024m06	Haver Analytics, WDI
$Tbill_t$	Six-month treasury bill rate	Percentage per Annum	2000m01-2024m06	ISF, WDI,IMF, Respective central Bank
IR_t	International reserves	Reserve Assets in Million USD	2000m01-2024m06	IFS,WDI, IMF, Respective central bank

Source: Haver Analytics, WDI, IFS.

1. Definition of Variables

The Real Exchange Rate (RER), Treasury Bills (T.B.), Consumer Price Index (CPI), and International Reserves (RES) are collected for the analysis in Table 1. The study uses monthly frequency data for the variables from 2000M1 to 2024M6 for selected emerging countries. We adjust the nominal exchange rate with inflation ($NE * \frac{P^D}{P^F}$) to derive the real exchange rate. N.E. is the nominal exchange rate, and $\frac{P^D}{P^F}$ is the ratio of domestic to foreign prices. The Consumer Price Index (CPI) is the general level of prices in the economy. Treasury Bills (T.B.) are short-time financial instruments that are provided by the government with a maturity period of one year or less. T-bills are yet to be considered risk-free investments because they are returned with full credit and the government's faith. The factors affecting T-bill prices are monetary policy, Investor Risk Tolerance (IRT), inflation and other macroeconomic conditions. International Reserves (I.R.) are the total gross foreign exchange reserves of an economy. According to the IMF, foreign currencies, special drawing rights and gold reserves are considered to be our I.R. includes bonds and other foreign currency deposits. These bonds and foreign currencies are kept by a nation's central bank and monetary authorities in the form of U.S. Dollar (USD), the British pound, the Euro (EUR) and lastly, the Japanese yen (JPY).

In time series data, various unit root tests have been used to check the stationarity conditions in Table 2. It is very important to know about the nature of data before estimating it, because if the data is non-stationary and we estimate it will show spurious results. We use ADF test to check stationarity.

V. Results and Discussion

This section presents the results of the GARCH and SVAR models. It starts by estimating the simple ARIMA model with AIC used for selecting A.R. and M.A. terms. Then, it estimates the GARCH-X models to compute the volatility in the exchange rate and presents the SVAR models' IRF (impulse response functions).

1. Discussion on Estimated Mean Equations

The fundamental assumption in the estimations of time series data is constant variance; however, the GARCH model is estimated in the case of violation of such an assumption. The estimates of the mean Equations (1) confirm that exchange rate changes are characterized by non-constant variance. Therefore, we model the series' variance through GARCH-X estimations.

Table 3 contains estimated coefficients for A.R. terms. It shows the mean equations of all selected emerging economies. The AR terms of Indonesia, Malaysia, Hungary, Russia and Egypt are to be optimal with AR(1) and AR(2) as per (AIC) criterion.

2. Discussion on GARCH-X Equations

The equation of the variance comprises the ARCH term and GARCH term, and the lagged growth of foreign exchange reserves is added as an exogenous variable (Table 4). Equation (6) shows that 6.3 per cent of the moment in variance explained by the ARCH term contains lag of variance, and 49 per cent of the moment in the variance of the exchange rate is explained by the coefficient of the GARCH term in Pakistan. Malaysia has witnessed a 28 per cent moment in variance through the ARCH term and a 54 per cent variation through the GARCH term. Similarly, Indonesia has observed 87 per cent variation through the ARCH term and 23 through the GARCH term. Meanwhile, in the case of Hungary, 16 per cent variation is observed

TABLE 2

Unit Root Test

Variables	Pakistan		India		Philippines	
	Log- Level	Log-Diff	Log- Level	Log-Diff	Log- Level	Log-Diff
ER	1.40	-11.72*	-1.94	-10.27*	-2.29	-7.55*
CPI	-1.41	-5.02*	-1.49	-7.14*	-2.32	-5.28*
TB	-1.24	-10.06*	-1.78	-8.71*	-2.37	-10.26*
Res	-4.21*	-8.74*	-1.89	-4.69*	-1.84	-6.48*
	Indonesia		Thailand		Turkiye	
ER	-1.34	-11.83*	-2.28	-7.44*	1.99	-12.43*
CPI	-4.00*	-7.65*	-2.29	-8.25*	-2.29	-8.25*
T.B.	-4.65***	-5.32*	-2.8	-6.29*	-2.81	-11.28*
Res	-1.65	-14.73*	-1.89	-4.27*	-1.27	-7.24*
	Malaysia		Egypt		Poland	
ER	-1.69	-10.53*	-1.85	-6.93*	-1.91	-10.90*
CPI	-2.65	-6.18*	-1.54	-5.73*	-2.6	-4.34*
TB	-2.14	-5.91*	-2.98	-14.12*	-5.92*	-
Res	-1.34	-5.20*	-2.15	-3.83*	-1.83	-4.49*
	Hungary		Ukraine		Russia	
ER	-1.91	-12.60*	-1.61	-15.21*	-1.68	-12.15*
CPI	-2.32	-5.93*	-2.3	-4.58*	-3.1	-4.91*
T.B.	-3.47**	-6.18*	-3.47**	-10.77*	-3.14	-8.54*
Res	-1.08	-15.84*	-2.13	-3.04*	-1.63	-6.67*
	Georgia					
ER	-0.21	-4.48*				
CPI	-2.14	-6.21*				
TB	-2.77	-16.39*				
Res	-2.13	-8.48*				

Source: Authors' estimation.

TABLE 3

Estimated Equations of Autoregressive (A.R.) Terms of ΔLn(ER)

Sr. No.	Country	Autoregressive Terms						
		Constant	$AR_{(1)}$	$AR_{(2)}$	$AR_{(3)}$	$AR_{(4)}$	$AR_{(5)}$	$AR_{(6)}$
1.	Indonesia	0.0023	0.1938	-0.2780				
2.	Malaysia	0.0000	0.4472	-0.1702				
3.	Hungary	0.0008	0.22	-0.0091				
4.	Russia	0.0045	0.4761	-0.0995				
5.	Egypt	0.0040	0.2583	0.0038				
6.	Pakistan	0.0034	0.2914	0.2112	0.1320			
7.	Philippines	0.0005	0.3180	-0.1059	0.0686			
8.	Thailand	-0.0008	0.4174	-0.1563	0.0506			
9.	Turkiye	0.0112	0.2742	0.0060	-0.0062			
10.	Ukraine	-0.0005	0.2288	0.0423	0.0486			
11.	India	0.0003	0.2416	-0.0424	0.0471	-0.1515	0.1577	
12.	Georgia	-0.0001	0.329	-0.0047	0.0217	-0.0974	0.0968	
13.	Poland	-0.0023	0.0599	0.0072	0.0277	0.0035	0.0083	-0.0375

Source: Authors' estimation.

TABLE 4

GARCH-X of Exchange Rate

Sr. No.	Country	Coefficients			
		α_0	α_i	β	θ
1.	Indonesia	0.00033	0.40778	0.38289	-0.00644
2.	Malaysia	0.00005	0.30925	0.53346	-0.00095
3.	Hungary	0.00002	0.04298	0.92567	0.00085
4.	Russia	0.00139	0.29976	0.06054	-0.01098
5.	Egypt	0.00126	-0.01734	0.54248	0.01329
6.	Pakistan	0.00011	0.29294	0.49898	-0.00115
7.	Philippines	0.00001	0.03176	0.91607	0.00021
8.	Thailand	0.00003	0.11662	0.74807	-0.00025
9.	Turkiye	0.00177	0.09296	0.58349	-0.02421
10.	Ukraine	0.00072	0.1845	0.50066	-0.00448
11.	India	0.00012	0.14593	0.43629	-0.00225
12.	Georgia	0.00018	0.11477	0.42244	-0.00108
13.	Poland	0.00071	-0.02911	0.57427	-0.00974

Source: Authors' estimation.

through ARCH, and 51 per cent is observed through GARCH. In line with these, Russia has spotted a 58 per cent variation through ARCH and 64 per cent via GARCH. However, the remaining countries, including Egypt, Philippines, Thailand, Turkiye, Ukraine, India, Georgia and Poland, have witnessed 1.2, 2.4, 8.7, 45, 16.7, 11.8, -3.4 and -0.8 per cent variation through ARCH term respectively and 56.2, 12, 74, 9.9, 50, 45, 55.8 and 58 per cent of variance through GARCH terms. The volatility has been estimated through the GARCH-X model, and the graphical representation of the ERV of each selected emerging economy is presented in Figure A-1 (Appendix). Sign-Bias, Negative-Bias, Positive-Bias, and Joint-Bias tests are reported in Table 5. The tests confirm that there is no bias in the estimations.

TABLE 5

Test for positive and negative shocks on Exchange rate volatility

	Sign-Bias	Negative-Bias	Positive-Bias	Joint-Bias
Pakistan	0.84	-0.21	1.44	2.17
	(0.40)	(0.83)	(0.15)	(0.54)
India	-0.82	-0.89	-0.85	1.52
	(0.41)	(0.37)	(0.40)	(0.68)
Indonesia	0.48	-1.58	1.29	4.72
	(0.63)	(0.12)	(0.20)	(0.20)
Philippines	0.14	0.60	-0.18	0.40
	(0.89)	(0.55)	(0.86)	(0.94)
Ukraine	1.44	0.49	1.48	3.65
	(0.15)	(0.62)	(0.14)	(0.30)
Malaysia	3.49	1.77	0.89	12.84
	(0.00)	**(0.08)**	(0.38)	**(0.01)**
Thailand	-0.97	-2.34	-1.26	9.02
	(0.33)	**(0.02)**	(0.21)	**(0.03)**
Turkiye	0.68	0.18	3.75	16.21
	(0.50)	(0.86)	(0.00)	(0.00)
Hungary	-0.07	0.07	0.39	0.38
	(0.94)	(0.94)	(0.70)	(0.95)
Russia	-1.36	-0.54	0.66	3.89
	(0.18)	(0.59)	(0.51)	(0.28)
Egypt	0.07	-0.31	0.11	0.13
	(0.94)	(0.75)	(0.92)	(0.99)
Georgia	-0.85	-0.83	0.38	1.51
	(0.40)	(0.41)	(0.70)	(0.68)
Poland	0.72	-0.67	1.89	4.09
	(0.47)	(0.50)	(0.06)	(0.25)

Source: Authors' estimation.
Note: Probabilities are given in parenthesis.

3. Discussion on the Impulse response functions of the SVAR model

The IRF for all the emerging countries are given in Figure A-15 (Appendix). The IRF indicates that the volatility of the exchange rate has a direct impact on exchange rate movements in Pakistan, India, Indonesia, Malaysia, Hungary, Egypt, Georgia and Poland. However, there is a negligible response to exchange rate movements due to its volatility in Thailand. Further, the shock of higher volatility resulted in appreciation of the exchange rate in the Philippines, Turkiye, Ukraine, and Russia. The response of the exchange rate to one standard deviation impulse in inflation in consumer prices is positive in the case of Pakistan, India, Indonesia, and Malaysia, whereas it is negative in the case of the Philippines, Turkiye, Hungary, Georgia and Poland. Monetary policy shock – one standard deviation increase in the Treasury bill rate causes an appreciation in Pakistan, India, the Philippines, Hungary, Turkiye and Poland; however, tightening of monetary policy envisages depreciation in India, Malaysia and Egypt.

There is a positive response of exchange volatility to the exchange rate movements in Pakistan, India, Indonesia, Philippines and Turkiye. This response is negative in Malaysia, Thailand, Hungary and Russia and volatility is indifferent to exchange rate movements in Ukraine, Egypt, Georgia and Poland. In response to an unanticipated shock in inflation, exchange rate volatility increased in Pakistan, India, Indonesia, Philippines and Turkiye. Volatility in exchange rates was contained during spikes in inflation in Malaysia, Thailand, Hungary, and Russia. The volatility in exchange rate remains unresponsive to the inflation in Ukraine, Egypt, Georgia and Poland. Further, monetary policy tightening resulted in higher volatility in the exchange rates in most of the economies except the Philippines, Thailand, Ukraine, Egypt and Poland, where volatility does not respond to unanticipated monetary policy shocks.

Inflationary pressures emerge in response to exchange rate depreciations in Pakistan, India, Ukraine, Egypt, and Russia, whereas the opposite response is observed in Indonesia, the Philippines, Turkiye, Hungary, and Thailand. There is a negligible response in the rest of the economies. Similar types of responses are witnessed in exchange rate volatility. Further, the analysis shows that economies characterized by volatility drifting away more frequently from their average value are contributing positively towards inflation.

VI. Conclusion

The study aims to explore the pass-through of unanticipated movements in levels and variance of exchange rate to inflation. With this objective, the first part of the paper quantifies exchange rate volatility with the GARCH-X model. Subsequently, we estimate the SVAR model to identify the response of inflation to a set of determinants. The exchange rate volatility has a direct impact on inflation in the economies where the volatility is relatively high, such as in Pakistan, India, Indonesia, the Philippines

and Turkiye. In economies characterized by flexible exchange rate systems and low volatility of exchange rates, volatility has either a negative or negligible impact on inflation. This study uses monthly frequency time series data from January 2000 to June 2024 of the real exchange rate, international reserves, consumer prices and Treasury bill rates/deposit rates of selected emerging economies (Pakistan, India, Indonesia, Malaysia, Philippines, Thailand, Hungary, Turkiye, Ukraine, Russia, Egypt, Georgia and Poland). A few of the variables of the different countries are non-stationary at log levels, whereas all variables are I(1), that is, stationary at first difference. The results of the GARCH-X model show that volatility of exchange rate is less common in those countries which have adequate levels of Foreign Exchange reserves to meet foreign liabilities. In contrast, the opposite is true for other countries. The findings regarding the impact of exchange rate movements on inflation are consistent with the economic theory as Pakistan, India, Indonesia, Malaysia, Hungry, Egypt, Georgia, and Poland have higher movements in exchange rates that result in a positive pass-through to inflation. Therefore, the study concludes that exchange rate stability plays an important role in controlling inflation in the emerging economies. Further, this study recommends that emerging countries focus on maintaining sufficient buffers of forex reserves and central banks must be independent while taking monetary policy decisions. The study implies that emerging economies should also focus on stabilizing their currencies so that the pass-through of exchange rate volatility can be managed.

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APPENDIX

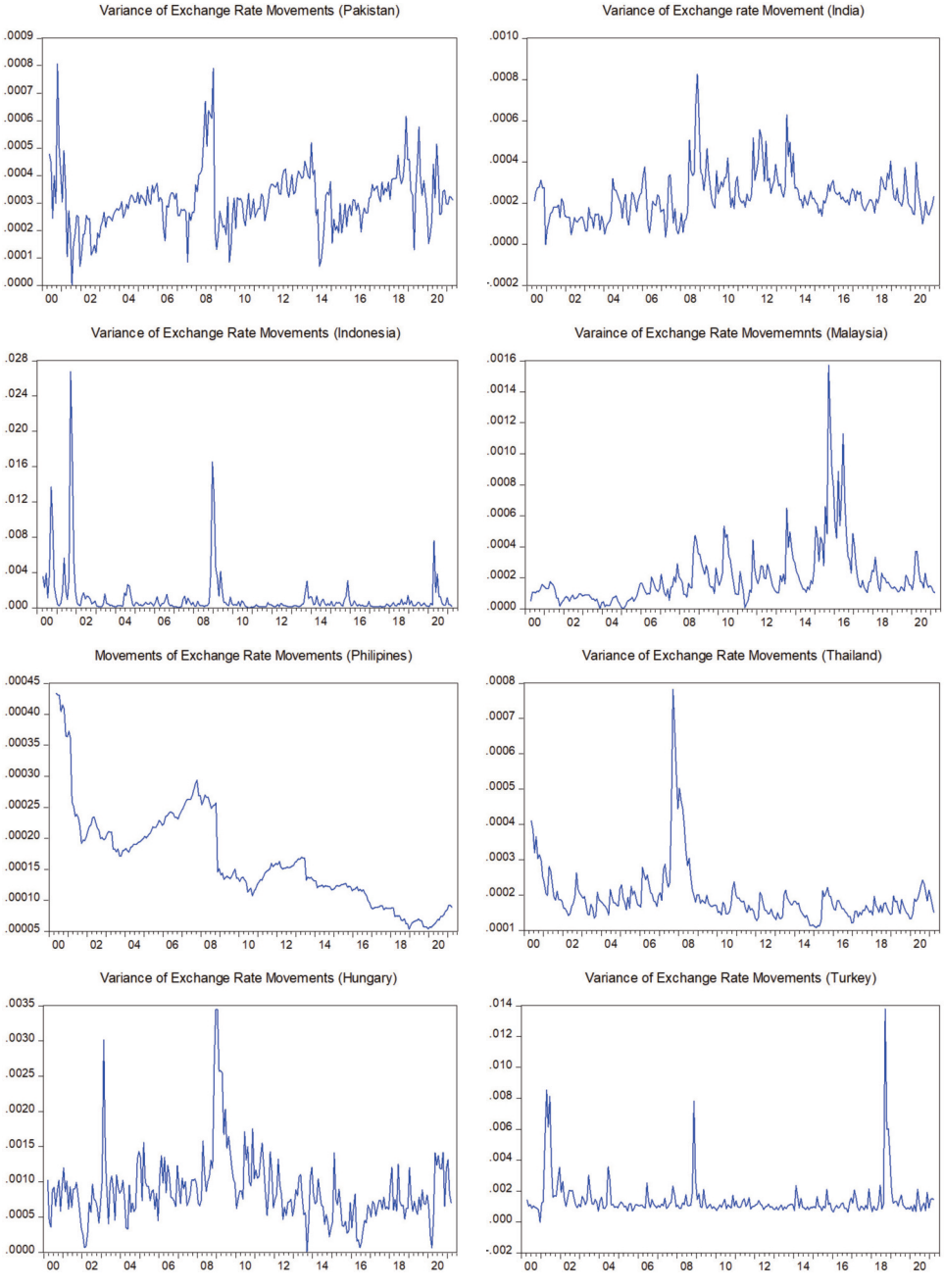
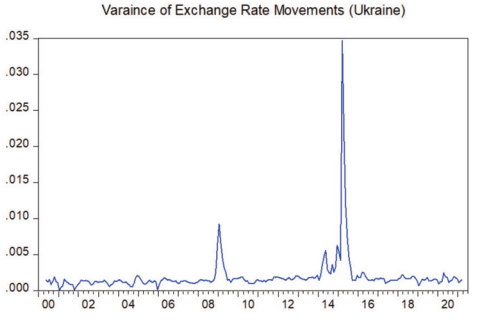
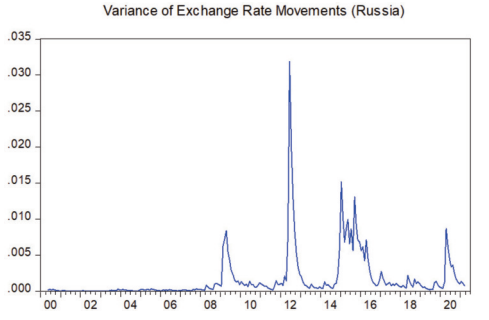
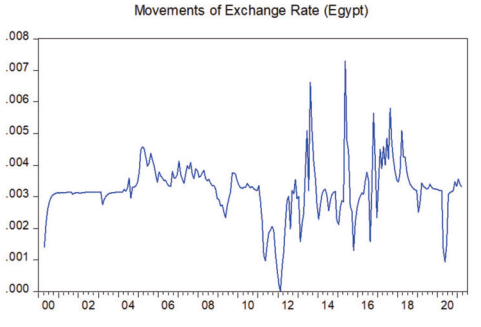


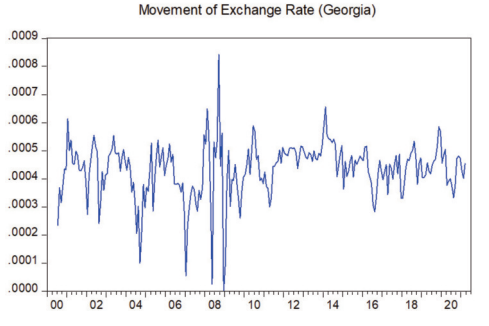
FIGURE A-1 *(Continued)*

Exchange rate Volatility of Emerging Economies









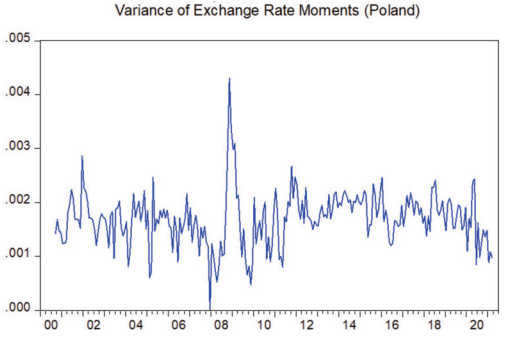


FIGURE A-1 *(Continued)*

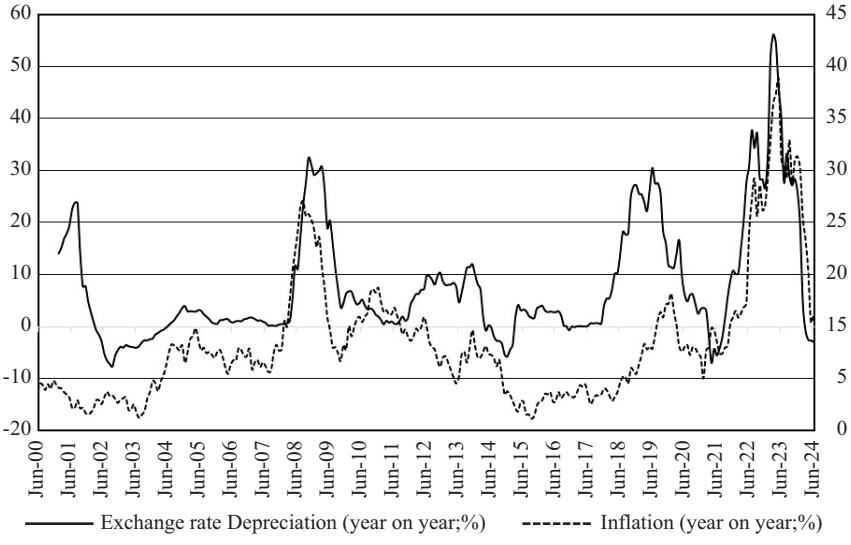


FIGURE A-2

Exchange Rate and Inflation (Pakistan)

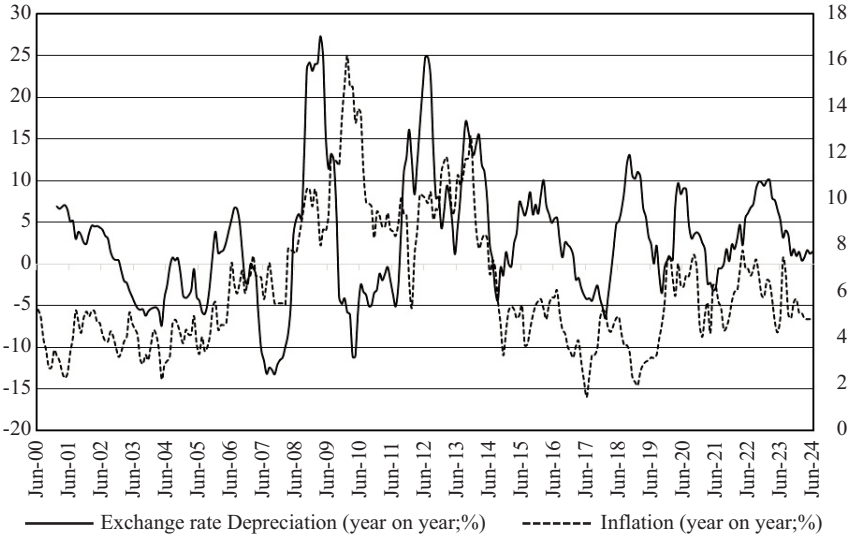


FIGURE A-3

Exchange Rate and Inflation (India)

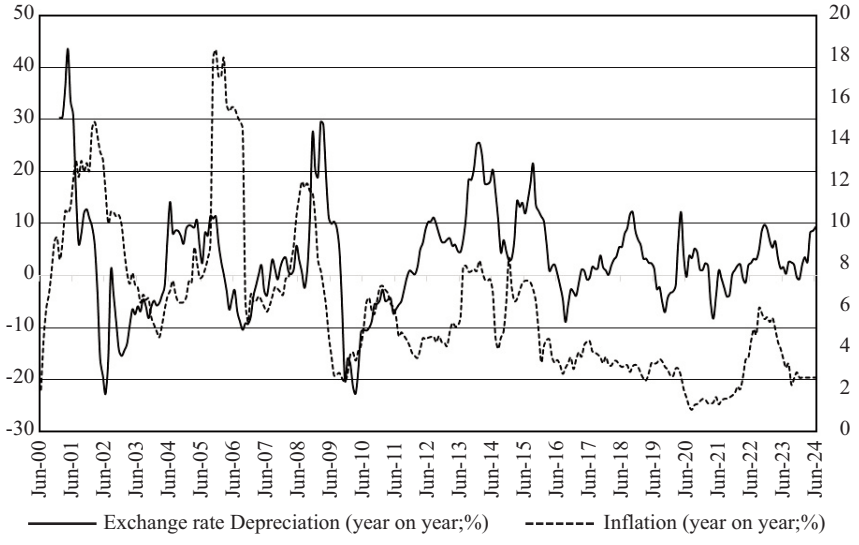


FIGURE A-4

Exchange Rate and Inflation (Indonasia)

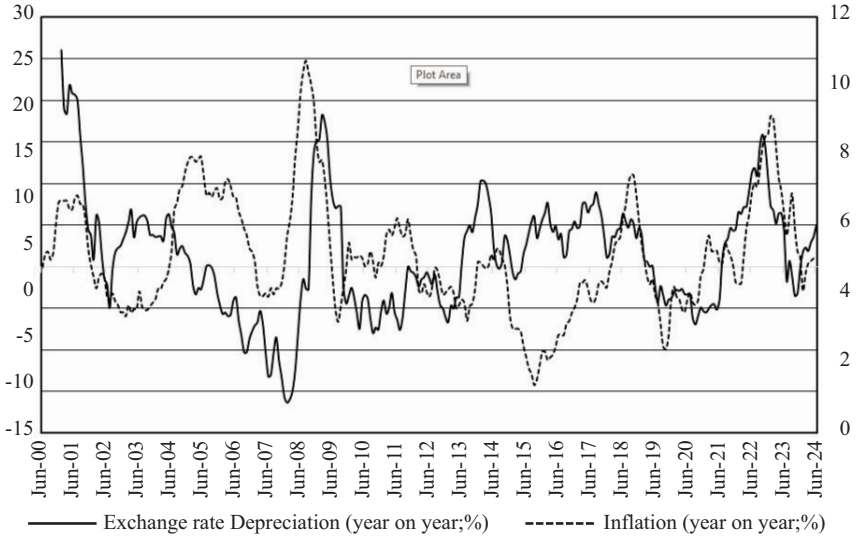


FIGURE A-5

Exchange Rate and Inflation (Philippines)

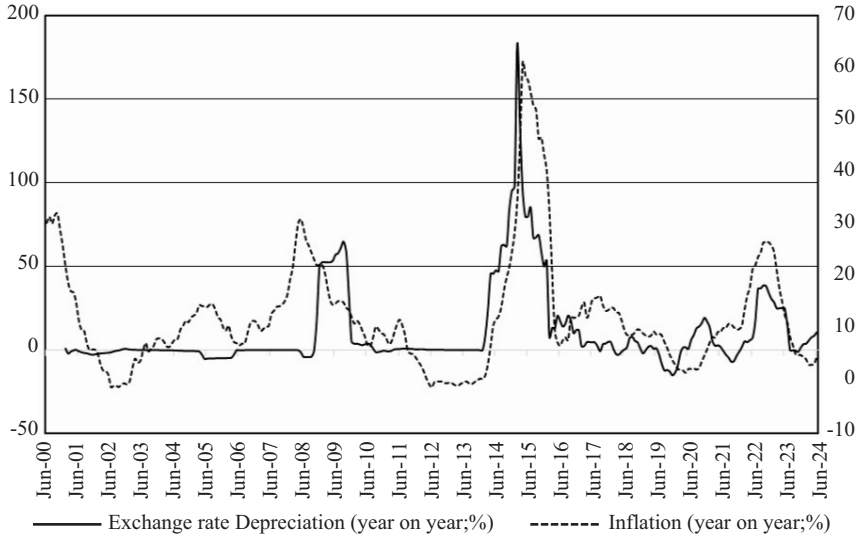


FIGURE A-6

Exchange Rate and Inflation (Ukraine)

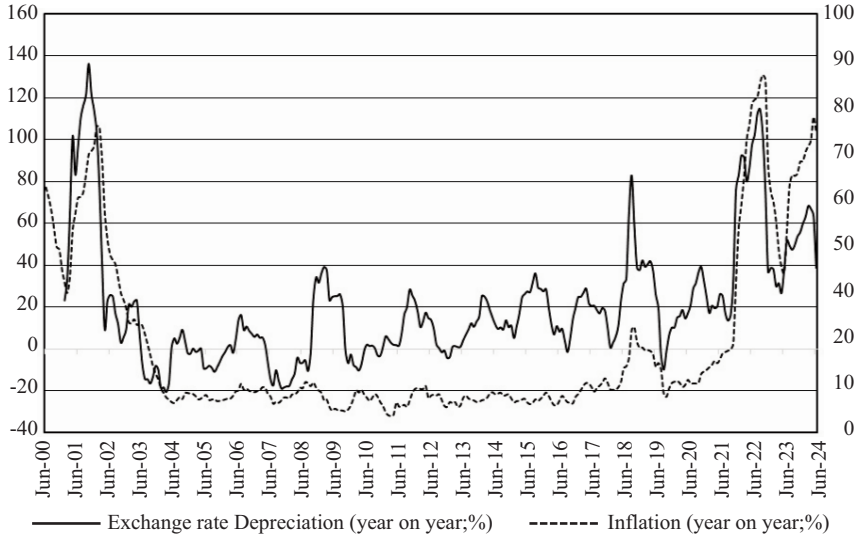


FIGURE A-7

Exchange Rate and Inflation (Turkeiya)

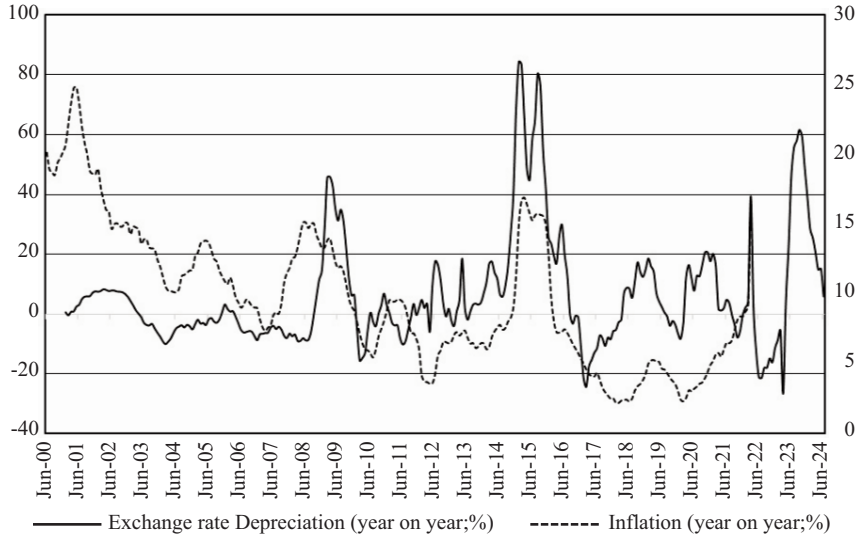


FIGURE A-8

Exchange Rate and Inflation (Russian Federation)

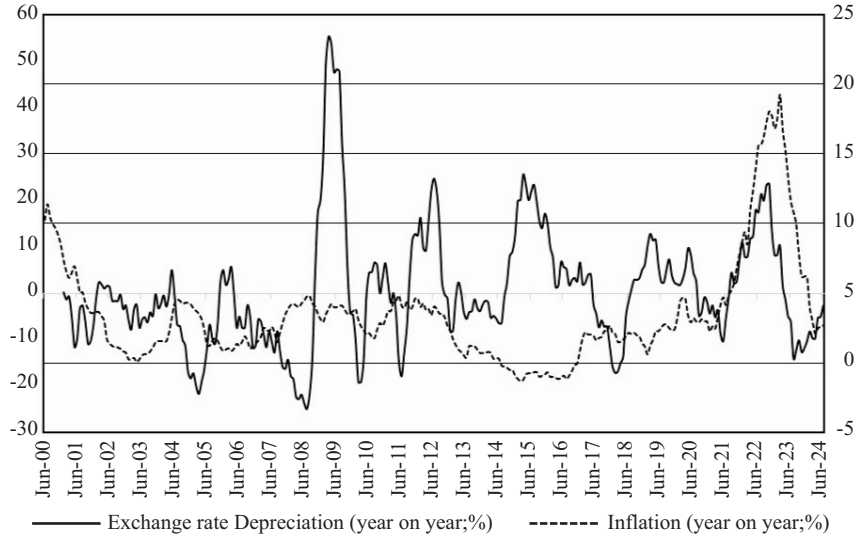


FIGURE A-9

Exchange Rate and Inflation (Poland)

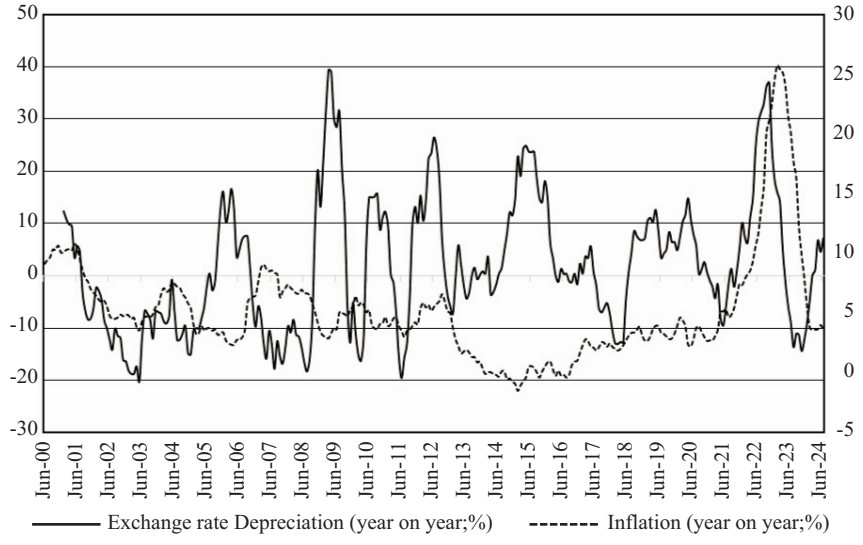


FIGURE A-10

Exchange Rate and Inflation (Hungary)

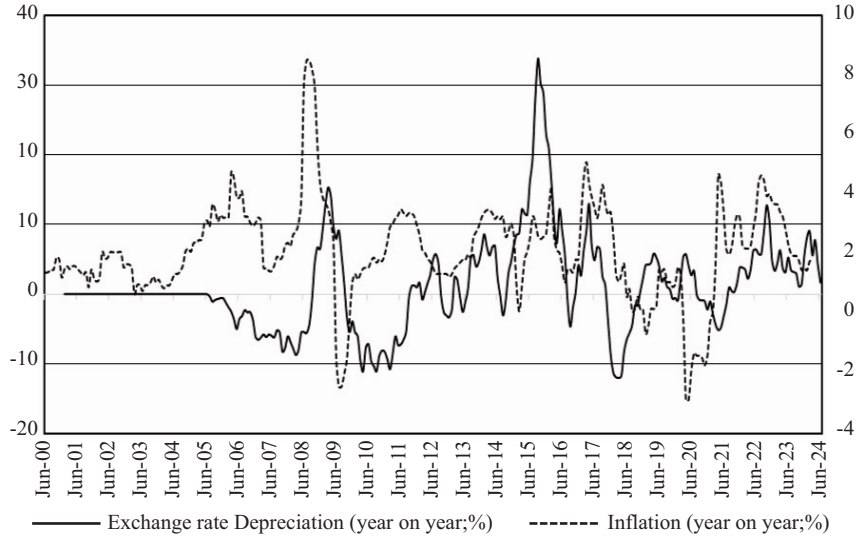


FIGURE A-11

Exchange Rate and Inflation (Malaysia)

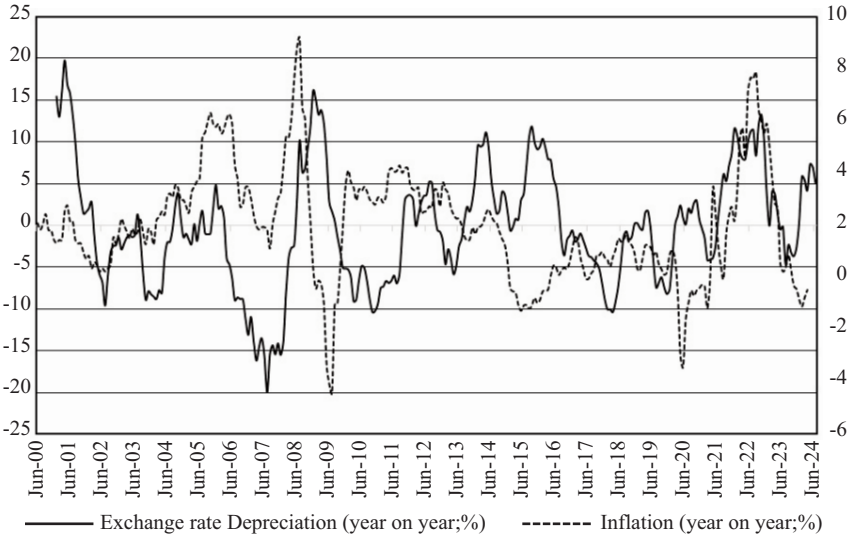


FIGURE A-12

Exchange Rate and Inflation (Thailand)

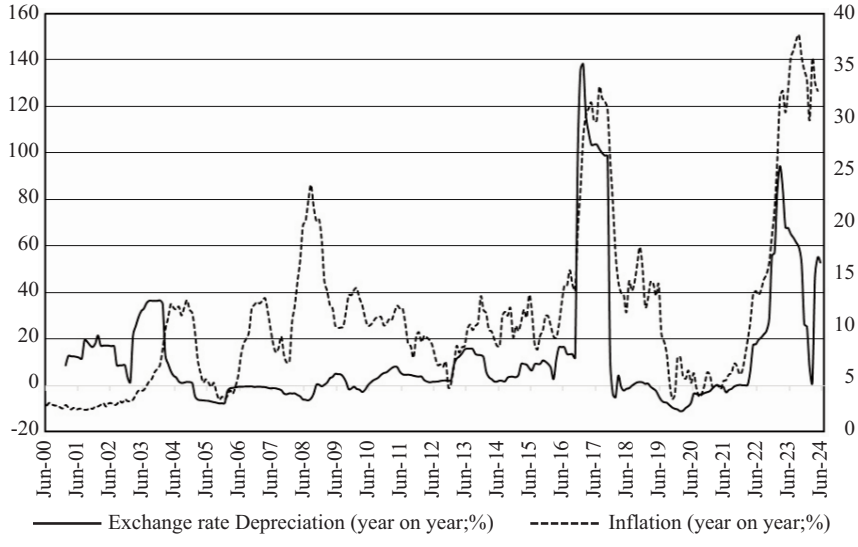


FIGURE A-13

Exchange Rate and Inflation (Egypt)

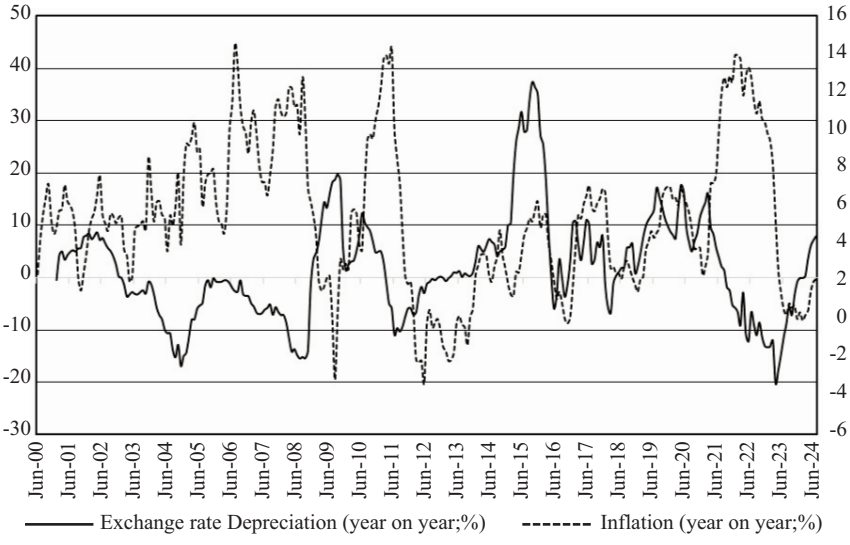


FIGURE A-14

Exchange Rate and Inflation (Georgia)

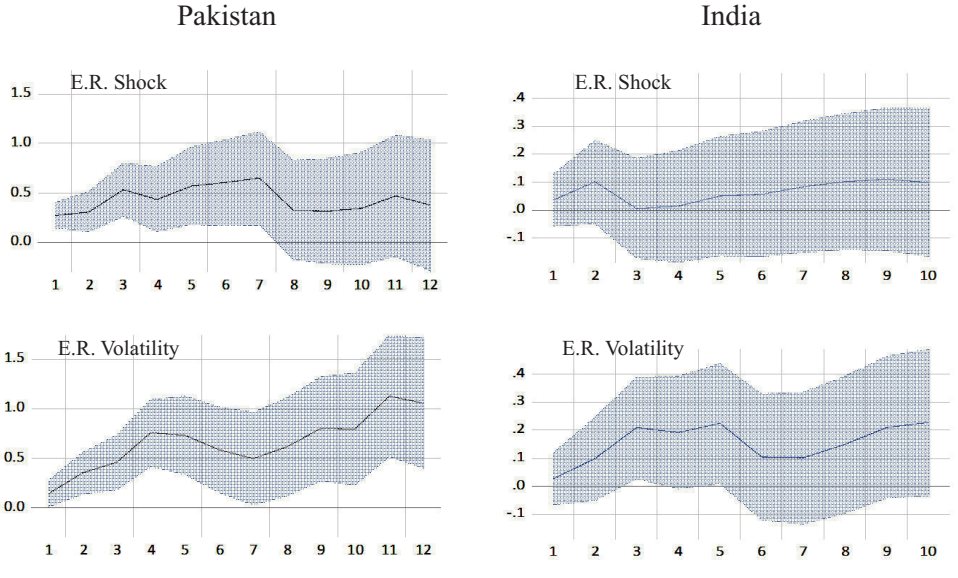


FIGURE A-15 *(Continued)*

Impulse Response of inflation to the shocks in exchange rate and volatility of exchange rate

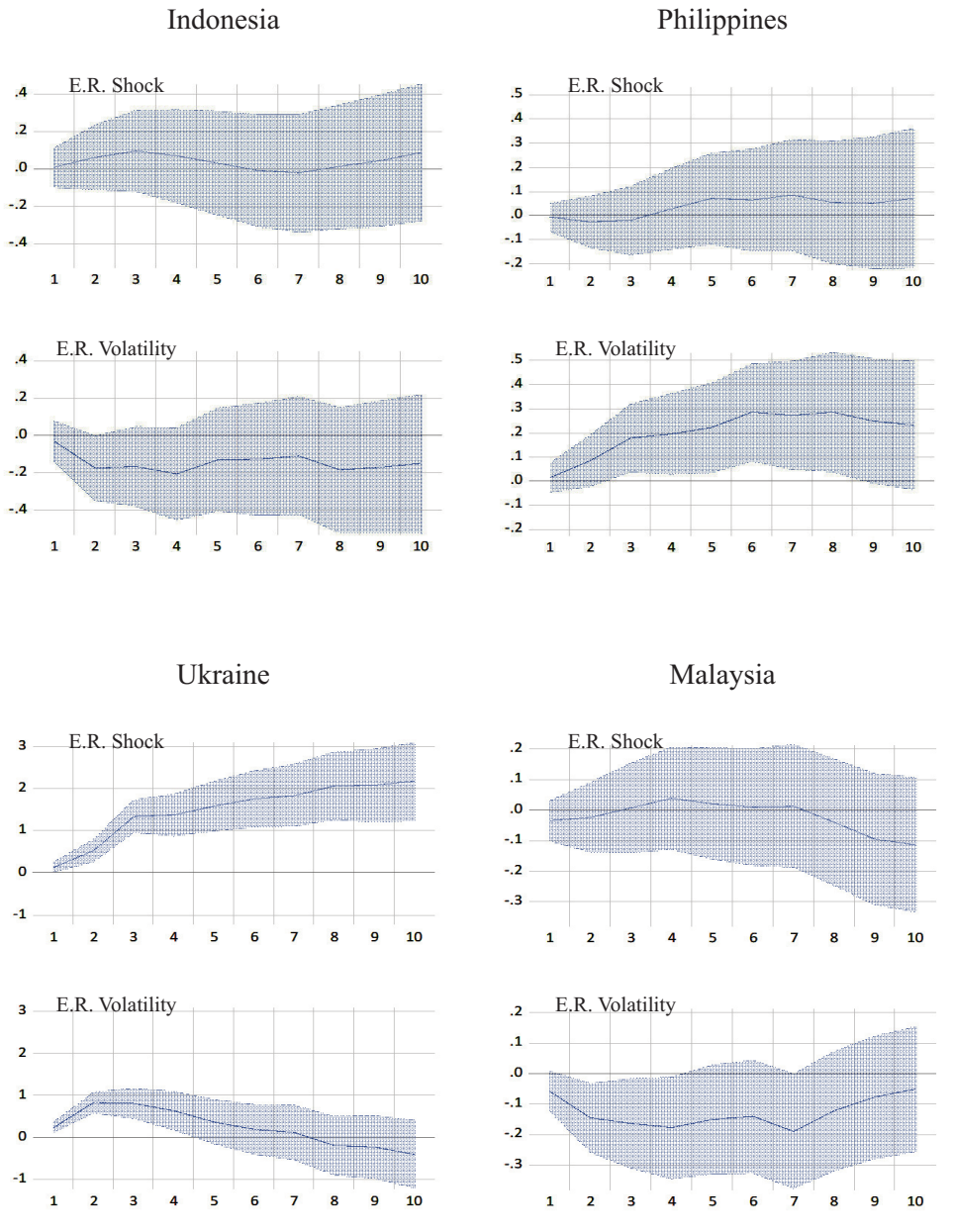


FIGURE A-15 *(Continued)*

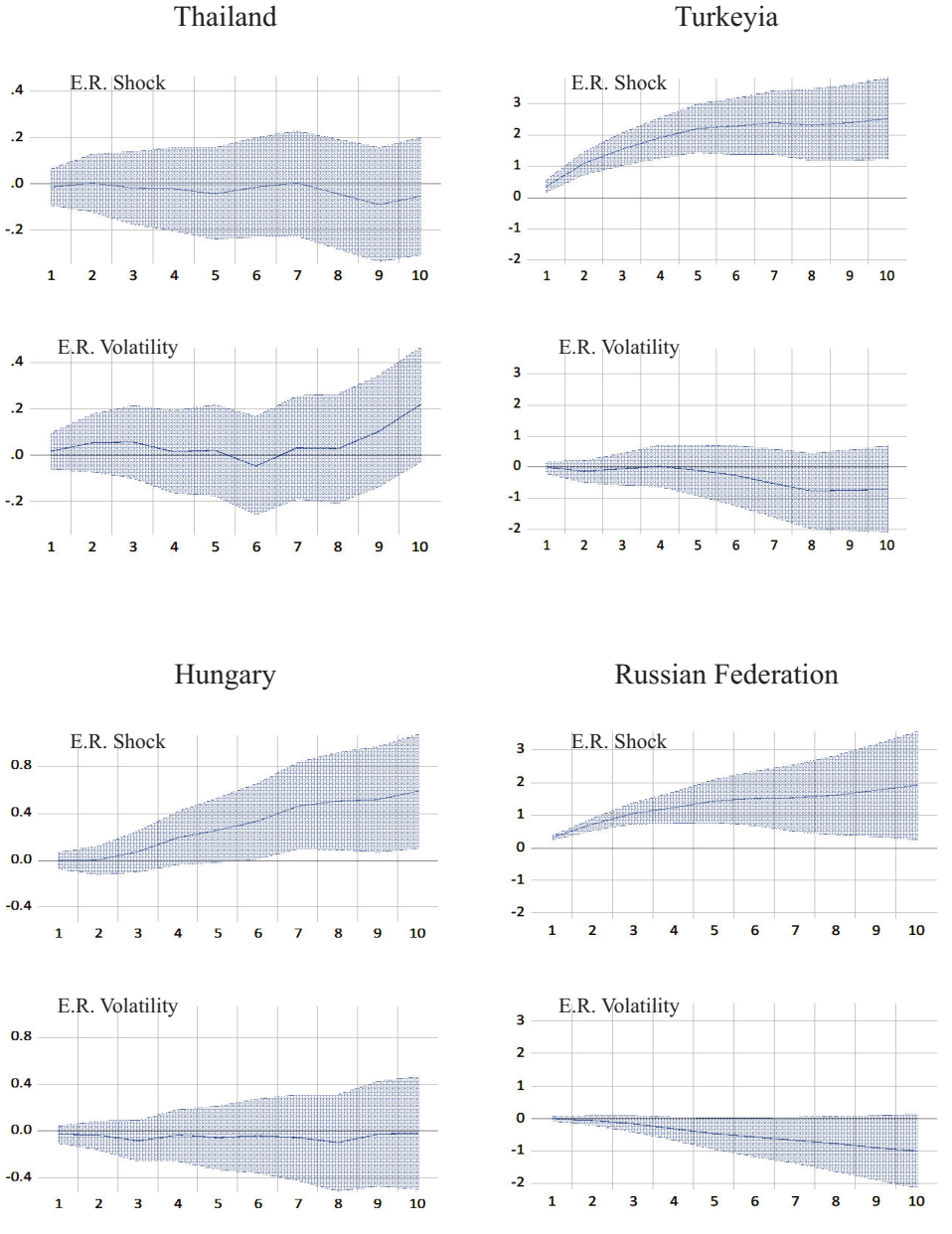
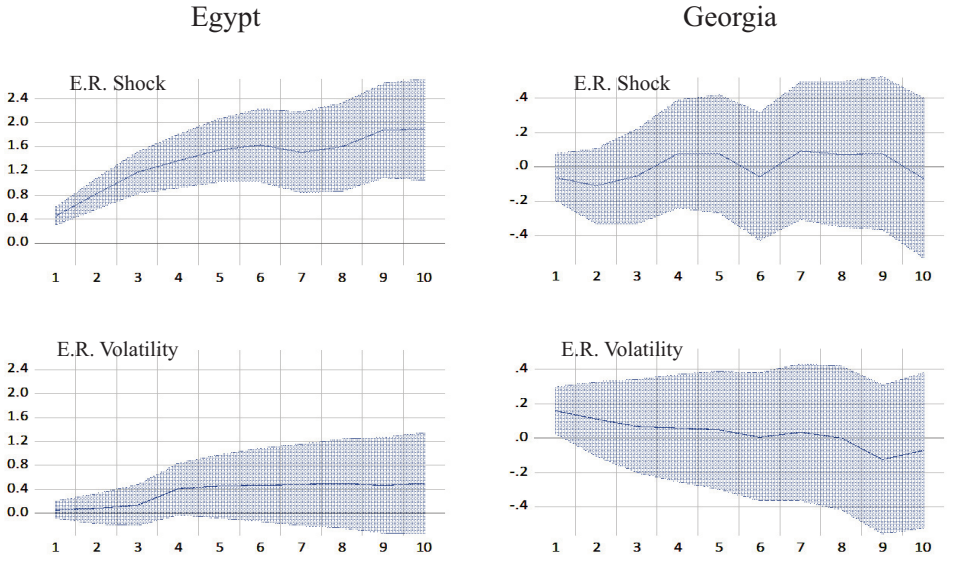


FIGURE A-15 *(Continued)*



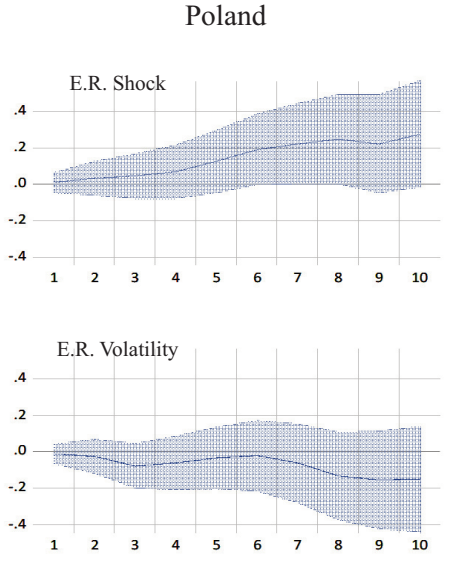


FIGURE A-15 *(Continued)*